sword-grass that cuts like a knife, known as "oom soof." The steamer could cut its own way through the latter in the presence of a current, as it would break up and float down stream. In the absence of current it does not float away, and obstructs the steamer by fouling the paddle-wheel. Another source of obstruction is a very light kind of duckweed which covers some of the small open pools.

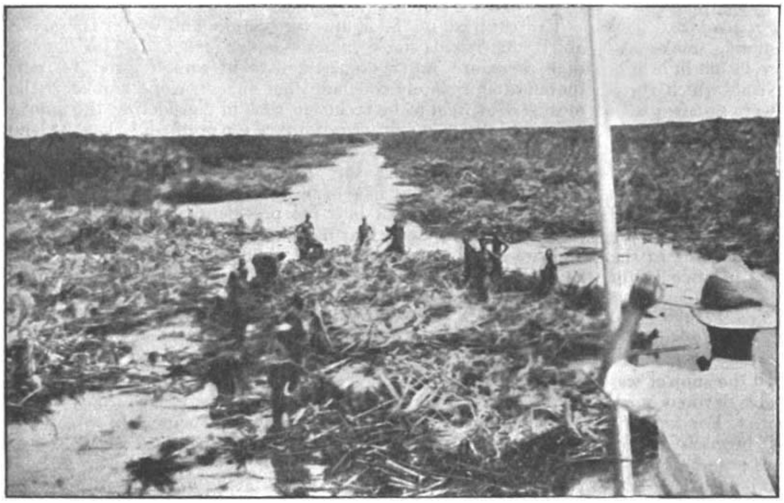

FIG. 1.—Steamer towing out a block of sudd.

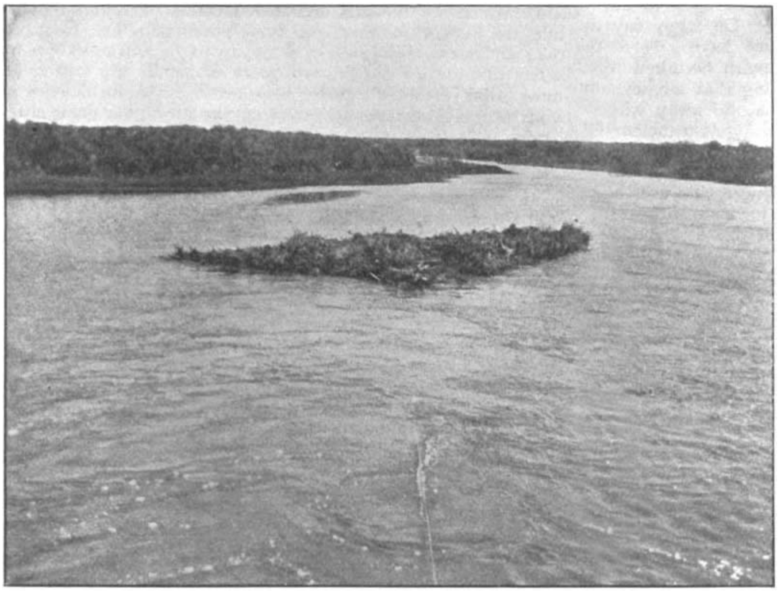

FIG. 2.—Block of sudd let go in open water.

THE TREATMENT OF SMOKE: A SANITARY PARALLEL.[1]

Introductory.

IN accepting the suggestion that I should take as my subject some aspect of the fog question, I have allowed the importance of the question to override the many considerations which I could adduce in opposition thereto. I propose to consider what demands sanitary reformers may fairly make upon practical men of science and others in regard to the mitigation of the evil effects of fog in towns, and incidentally to point out what demands in this connection, desirable in themselves, must be regarded as beyond the scope even of scientific ambition.

For the sake of clearness, what I have to say is cast in the form of a parallel or analogy. The smoke in fog is the element of the problem to which special attention is directed, and the smoke is regarded as a species of domestic or industrial refuse which has to be removed somehow or other. The removal of smoke is a problem not dissimilar in its fundamental character from that of the removal of sewage, and in what I have to say I keep in view the analogy that exists between the elements of these two problems. I choose the problem of the removal of sewage for this purpose, because it is a problem in which sanitary reformers have achieved gradual but conspicuous success during the nineteenth century, and even within the memory of the present generation, to the great advantage of the whole community.

In all matters concerning the disposal of refuse, we progress by slow degrees from an individualist to a socialist point of view. Occasional illustrations of reckless indulgence of the extreme individualist view as regards the disposal of other forms of refuse might be quoted, and at this day it is no great exaggeration to say that we all act with similar recklessness with regard to our smoke; we throw it into the atmosphere and leave to beneficent chance the question whether or not it injures our neighbours.

In large towns, we have travelled very far in the path of development from the original instinct as regards the problem of the disposal of sewage-polluted water, but there has been no corresponding progress in the disposal of smoke-polluted air. In London, at a cost to the community of 211,000*l.* a year, or 1·38*d.* in the pound on rateable value, nearly a million tons of sewage are removed day by day for about 600,000 houses—about a ton and a half on the average for each house. In the same period, viz. each day, in winter, each house throws into the atmosphere on the average perhaps ten tons of smoke-laden air, or a total quantity of five million tons of smoke-laden air for the inhabited houses of London per day, or possibly seven millions of tons per day if we include factories. The actual weight of solid soot which gives colour and body to the smoke is a very uncertain quantity; it may in the worst cases amount to nearly 3 per cent. of the coal consumed, and the houses of London probably get rid of 300 tons of solid refuse every day by throwing it up the chimney. It is mixed with much larger quantities of other more or less injurious products of the combustion of coal, complete or incomplete, but it is with the soot, which alone darkens and defiles, that I am primarily concerned.

The Initial Stages of the two Problems.

The difference of our attitude towards these two problems is very conspicuous, yet physically speaking the whole difference between the problem of the removal of sewage and that of the removal of smoke on similar lines lies in the distinction that sewage naturally goes downwards, whereas, in the first instance, smoke goes upwards. If the smoke of our fires had been in the habit of falling downwards and finding a lower level instead of rising to a higher level and making its way up the chimney, we should long ago have been driven into solving the problem of its disposal, as we have been driven to deal with the disposal of sewage, no matter how great the volume might be.

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[1] Abstract of a lecture to the Sanitary Congress at Manchester by Dr. W. N. Shaw, F.R.S.

In days not so very remote, the arrangements for the disposal of smoke might be regarded as comparatively in advance. The genius who first put in practice the idea of confining smoke to a narrow flue specially built for it wrought a revolution in house-building. There are still archæological survivals which show that before his day there were architects who were satisfied with the more simple provision of a hole in the roof, and there are even traces extant of a still earlier architectural style of inhabited dwelling in which such rudimentary provision as a special opening for smoke did not exist. I do not attempt to describe the corresponding stages in the development of the means of disposal of other kinds of refuse; they could be traced—*gärdy loo* is the survival of a warning with special meaning in the Scottish capital—and examples of present-day practice might be adduced in illustration. But while the disposal of sewage has been generally though slowly progressive since the first commissioners of sewers were appointed in 1531, the invention of the chimney seems to have been so successful as to paralyse mechanical enterprise in that department until the subject was taken up in later years by cowl makers, who have devoted much ingenuity to the improvement of the terminal outlet. For domestic purposes, the simple chimney, with or without the assistance of a cowl, remains a sufficiently effective apparatus; the practice of using it to throw smoke into the atmosphere to be carried away by any currents of air that may arise is universal.

Demands beyond the range of Scientific Ambition.

One of the incidental obstacles to a scientific treatment of the smoke question is that at first sight the atmospheric currents appear to perform the duties of general scavenger with such exemplary efficiency that few people give any thought to the general success or failure of the method itself. On foggy days we become aware of the nuisance which we have created, and accordingly desire that steps should forthwith be taken to remove or prevent fogs, with the understanding that whatever does away with the fog will, at the same time, do away with the smoke nuisance. Now the prevention of fog as a meteorological phenomenon is one of the demands which I think we are not legitimately entitled to ask of practical men of science; it is beyond the ambition even of physical science. To use the parallel further, it would be just as reasonable for us to throw all our refuse into the streets and, when we found that it accumulated beyond endurance, demand of men of science that they should provide showers at suitable intervals to wash it all away. The well-known meteorological conditions for the formation of inland fog are my justification for this opinion.

Nor can we hope for the removal of fog by the actual removal of the foggy air of London. I have on several occasions seen suggestions which seemed to regard such a scheme as possible, but I have never been able to understand where the air would be sent to and by what it would be replaced. Any such proposal has always seemed to me to come perilously near to a scheme for sweeping away the Atlantic with a mop. The removal of foggy air from the streets is as hopeless a matter as the prevention of fog, and when once smoke has been allowed to be discharged into the free atmosphere, all chance of removing it is gone.

Gravity of the Smoke Nuisance.

It is not only on foggy days that the method of leaving the atmospheric currents to act as the smoke scavengers fails. In large towns, the system is generally speaking inefficient. In support of this assertion, I quote from the figures giving the average amount of sunshine recorded at a large number of stations in the British Isles during the twenty years from 1881 to 1900, a comparison between the records for London and the average of those for other places in the southern district of England. The amounts given as percentages of the possible duration of sunshine for the several months are as follows:—

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
London ...	10	15	23	31	38	36	38	39	34	24	14	9	per cent. of possible duration.
Average for the southern district of England ...	21	28	38	42	46	43	46	47	44	37	24	21	do.
London loss in approximate figures	½	½	⅓	¼	⅙	⅙	⅙	⅙	¼	⅓	½	½	

It appears that in summer London loses one-sixth of its sunshine, and presumably also about the same fraction of its daylight, on account of its smoke, while in winter its loss amounts to one-half for a similar reason.

The contrast of the figures for summer and winter is remarkable. As regards smoke, the difference rests chiefly on the fact that there are fewer domestic fires in summer, and we may therefore legitimately conclude that the domestic smoke is the most serious item to be reckoned with in considering the smoke question. It is, in fact, two-thirds of the problem.[1] Anyone who wishes to satisfy himself as to this aspect of the question can easily do so. During the past winter, Captain Carpenter, R.N., D.S.O., who has been conducting an inquiry for the Meteorological Council into the prevalence and distribution of fogs in London, found that the Victoria Tower at Westminster and St. Paul's Cathedral—two buildings a mile and a half apart as the crow flies—are invisible the one from the other until March is well established. There is here no question of persistent fog in the meteorological sense; even on windy days, when fog is meteorologically impossible, there is no possibility of seeing a distant object in London on account of the domestic smoke from the thousands of chimneys, each using the primitive plan of pouring its refuse into the atmosphere. Not only is the magnitude of the task too great, but the manner in which the atmosphere deals with it is not by any means satisfactory. It does not consume or annihilate the smoke, or render it harmless; it carries its load a little way, longer or shorter according to the state of the weather, and then drops it regardless of consequences. The results are easily recognised. Sooty rains are not by any means an unusual phenomenon, and that is not all. A special type of heavy, dull, oppressive atmospheric condition may generally be noticed on the lee side of all great smoke centres.

That we endure the presence of all this burden of refuse in the air which we breathe, and which carries all our daylight, while we have eliminated the corresponding refuse from our streets and our drinking-water, is partly to be accounted for by the fact that ideas about the treatment of smoke are still in an almost primitive stage; partly also because the inefficiency of the atmospheric currents for renewing the air of our great cities in ordinary weather is not fully realised. It is only during persistent fog that the failure is complete and unmistakable. On foggy days when we thrust our refuse into the atmosphere, it simply descends upon our heads and into our houses. We might almost as well have no chimneys at all. The experience of Sir W. Thiselton-Dyer at Kew could easily be shown to be the experience of all of us who live in large towns if we were able to make such measurements as he made in 1891, when after a week of fog he found upon the greenhouses at Kew—a comparatively favoured atmospheric position for London—a deposit of tarry matter at the rate of six tons to the square mile.

So far as I know, the only practical suggestion put forward by those interested in the abatement of the smoke nuisance is to invite householders and compel factory owners not to make smoke, or to consume it if they make it, or, in the third event, to make as little as may be, consistently with their own interests. As regards factories, very considerable improvement has followed these efforts, and I do not wish to be adversely critical when I point out, first, that the distinction drawn between the factory and the domestic establishment is unscientific if the smoke nuisance is to be really removed, and secondly, that that was not the plan adopted in the parallel case of the removal of sewage, for which the local authorities have used common funds.

Further Development of the Analogy.

In following the analogy somewhat further, I suppose it agreed that the proper course to be pursued is, not merely to

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[1] The corresponding figures for Glasgow as compared with Douglas (Isle of Man), the only other station in the same meteorological district, indicate that domestic smoke is only responsible for one-half of the smoke problem in the Glasgow district, though the want of stations makes the comparison incomplete. The figures are as follows:—

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Glasgow sunshine	10	17	24	30	33	31	28	28	26	22	11	8	per cent. of possible duration.
Douglas sunshine	21	26	37	43	46	43	39	38	38	32	24	18	do.
Glasgow, loss in approximate figures ...	½	⅓	⅓	¼	¼	¼	¼	¼	⅓	⅓	½	½	

prevent smoke by penal legislation, but to encourage the interception of smoke and the removal of the sooty particles before the air is allowed to escape, and I will subsequently call attention to the share which a local authority could fairly take in such an enterprise. I do not say that this is the only or the best mode of dealing with the question; I only consider whether it is, *prima facie*, practicable enough to justify our including inquiries with regard to it in the demands that sanitation may reasonably make upon science. I offer a few considerations in mitigation of criticism of this venturesome proceeding.

First, I am only practically recalling a suggestion made many years ago. A proposal for the treatment of smoke by the erection of municipal chimneys was made in Manchester by Mr. Peter Spence (*Proceedings* Manchester Lit. and Phil. Soc., 1857). It is precisely in such a city as Manchester—a city of fogs and smoke, but also the city of Dalton and of Joule—where the facilities for the association of scientific experiments with real practical life have been so wonderfully developed that an enterprise of this character could be taken in hand.

Secondly, the present method of dealing with smoke is by no means final, although, as I have said, it has marked a most important stage of progress. One of the most conspicuous features of London architecture is the enormous variety of smoke cowls, in all stages of dilapidation, to be seen surmounting the roofs. Almost every chimney stack is a sort of museum of contrivances for improving the action of chimneys. The mere exhibition of so many contrivances can only mean that smoky chimneys are not by any means so rare as they might be under more favourable mechanical conditions. On that very account, if on no other, the separate chimney method of dealing with smoke is not suited to the circumstances of large towns.

Thirdly, the designer of a factory takes a further step in advance in the treatment of smoke, and provides a single smoke stack for a considerable number of independent fires. The separate opening of each chimney of the domestic house into free air is, therefore, not absolutely required for the removal of smoke. The factory builder is not always successful in using his chimney for preventing smoke, but he is successful in leading the foul air of many flues into one channel which might afford an opportunity for depriving the smoke of its soot.

Moreover, arrangements for propelling air mechanically are becoming every day more extended. Some of them as employed in various systems of ventilation are quite as elaborate as any that would be required to deal with the smoke of an ordinary house or block of houses. There is no sufficient distinction to be drawn between coal smoke and other forms of refuse that foul the air to make it necessary to use one system for the former and a different one for the others. It thus seems almost certain that if the domestic architect had sufficient encouragement to make the attempt, he would not find the plan of dealing with household smoke by the method of the factory chimney or by mechanical propulsion beyond the range of practical physics.

Some Particulars of the Smoke Problem.

For purposes of comparison, I next consider what is the amount of smoke-laden air with which we have to deal. It is difficult to give any but the roughest estimate. I assume that on the average every house of the 600,000 rated for the municipal purposes of London has two fires burning, and therefore two chimneys emitting smoky air, for twelve hours each day, and that each chimney uses and defiles 10,000 cubic feet of air per hour. If these estimates are inaccurate, we can at least ask scientific men to correct them. On these assumptions, every "working chimney" delivers 4·2 tons of smoky air per day; every house, on the average, 8·4 tons. We thus obtain the estimate of five millions of tons of smoky air sent up the household chimneys of London in one day. Allowing for the 14,500 factories of London, which are not altogether innocent in the matter of smoke, as equivalent each to thirty house chimneys, we get an additional two million tons of air fouled with smoke; that is, in the aggregate about seven million tons of air are used per day in London to carry away smoke[1] as compared with about a million tons of water to carry away sewage. The cost of dealing with the sewage is about 600*l.* per day. Supposing that a ton of dirty air could be "treated" for the same cost as a ton of sewage, the cost of clearing the air of London might be set down at 4200*l.* a day, equivalent to to a rate of 10*d.* in the pound.

To move air is a comparatively cheap matter. An electrically-driven fan will do the day's work of a single chimney, as regards smoky air, at a cost of about a penny, under suitable conditions. A single colliery fan has been made to deliver as much as 200,000 cubic feet of air per minute, and its output therefore amounts to about 10,000 tons a day, or sufficient to carry the smoke of more than 1000 London houses on the scale mentioned above. Five hundred of such fans would carry the household smoke of the whole of London. It would mean a huge aggregation of power, but London means the same.

These figures show that although the volume of smoky air is vastly larger than the volume of sewage, yet the cost of dealing with it for the purpose of treatment may not be of an altogether different order of magnitude from the cost of the manipulation of London sewage, and the point at which I wish to arrive is, that we are justified in asking practical men of science, as a first question, whether the treatment of smoky air, on a plan somewhat similar to the treatment of sewage, is mechanically possible within reasonable limits of original outlay and current expense.

Limitation of the Analogy.

Beyond this point it would be necessary to diverge in the treatment of smoke from the plan adopted with sewage, both as regards the special method of dealing with it and as to the part which the local authorities should take in encouraging and assisting the purification of air.

I do not suppose that it is possible to establish a few main drains for smoky air corresponding to the main sewage drains, and to use one or two cleansing stations for purifying the air from smoke; but it might be possible to achieve a similar result by a large number of systems on a correspondingly small scale, and the systems might be some of them municipal and some private. A single block of houses might have means for drawing off the smoke from all its fires into a chamber wherein the smoke could be treated,[1] before the fouled air was allowed to pass into the atmosphere, and if such a system were mechanically feasible we should then be able to put a second question to practical men of science, viz., whether it is not possible completely to deposit from the air as it passes on its way the solid particles which form the smoke. It has been shown that sooty particles coagulate under mechanical action, and some years ago Sir Oliver Lodge showed experiments on the deposition of smoke in a closed chamber by means of electricity. I should now like to ask whether it is not possible to make a further advance in this direction. I do not demand that no smoke shall be produced. I think that people may prefer to pay the cost of abstracting the smoke if they enjoy the free use of open fires, to which, in England, we are so much attached.

The Question of Cost.

If men of science give us satisfactory answers as to the physical possibilities, the question then becomes one of cost. Suppose that the cost amounts to the equivalent of a tenpenny rate. Would ratepayers be willing to expend a sum of that magnitude for the purpose of eliminating smoke from the atmosphere of London or Manchester?

In considering this aspect of the question, it should be remembered that the result, if successful, would have some economies to set down per contra.

A bad fog in London, according to the *Times*, may cost 5000*l.* a day for additional gas alone; to that we have to add the loss due to interference with traffic and other incidental items. I have seen the cost of a day's fog estimated variously at from 20,000*l.* to 50,000*l.*, and the cost per annum is set, I think by Mr. Rollo Russell, at from three to five million pounds. If any of these estimates be true, the equivalent of a tenpenny rate would obviously be a very cheap substitute for the smoke of London. Certainly, whatever may be the material damage of a day's fog, the moral and intellectual damage should be reckoned as no inconsiderable addition, and if the indirect results of the dirt of London smoke could be avoided, even an additional tenpenny rate might be found acceptable to a majority of ratepayers.

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[1] A layer of air 60 feet thick over the 75,000 acres comprised within the administrative county of London would weigh about 7,000,000 tons. The calculation suggests that on a day of dense fog, when there is very little horizontal movement of air, there is a more or less complete circulation of the air through the chimneys and back again to the streets and houses during the hours when chimneys are active. Dr. W. J. Russell's analyses of air during fog lend support to this suggestion.

[1] The plan of using a single chimney for a building comprising a chemical laboratory and suite of offices—sixteen rooms—has been carried out at the Manchester Alum Works in pursuance of Mr. P. Spence's idea.

Incidental Advantages.

A system such as that indicated would have some incidental advantages. It would provide a persistent and calculable system of ventilation that would enable hot water or steam pipes to be used advantageously much more generally than they can be at present, and afford other facilities corresponding to those of an efficient system of drainage with a copious water supply.

Contribution of Local Authorities to the Solution of the Problem.

Hitherto the powers of local authorities have been restricted to fining conspicuous offenders, and the system of penalties for conspicuous failure is not fully effective; it might be replaced advantageously by a system of rewards for success. For the sake of definiteness, I have set down the contribution of the local authority as equivalent to a tenpenny rate, though it would not seem practicable for it to contribute in the same way as it does to the solution of the sewage question by maintaining a single municipal system. It might contribute effectively by allowing a specific *reduction of rate* on those properties within its area which were so arranged as not to add to the pollution of the atmosphere by smoke.

If the questions which I have mentioned are to be asked, it is essential that they should be put in such a manner that practical men of science may be encouraged to work out effective answers, and for that purpose they must make experiments. In the practical applications of science on the large scale, experiments are very expensive, and the only way of getting them performed is to take care that they are remunerative to somebody if successful. In this matter the local authorities could be of great assistance if they were willing to adjust their rating in what seems to me a reasonable manner. At present the incidence of rating is such as to discourage all experiments of this kind. If an enterprising architect were to erect a block of buildings and provide it with means of delivering its used air free of smoke at a substantial outlay, I presume the local authority would increase the rateable value of the property on account of the outlay, and thus fine the owner some considerable sum per annum for his enterprise. The owner would also be placed in the unfortunate position that whereas by avoiding smoke he had conferred as much benefit upon all his neighbours as upon himself, he would have to pay the whole fine of increased ratal himself, and would still have all the disadvantages of his neighbours' smoke.

I would suggest that instead of pursuing so unreasonable a course, the local authorities might recognise public spirit of this kind by reducing the assessment of a property that, to the satisfaction of its neighbours as well as of a surveyor or inspector, produced no smoke, so that the rates upon such a property should be decreased by, say, 6*d.* or 1*s.* in the pound instead of being increased. This would afford direct encouragement to practical men of science to design and keep in action means for the prevention of smoke, and would lead to gradual improvement.

It would naturally appeal with the greatest force in those quarters where rateable value is high and the advantage of open fires relatively small, and in such places it would be really worth while for practical men to make a serious effort to qualify for the reduction of rate. In the City of London, for example, there must be many properties with very high rateable value the facilities of which for contributing smoky air are already limited to one hot-water furnace and a few open fires. For such establishments it would be an experiment on a very small scale to arrange matters to obviate smoke altogether and satisfy the surveyor or inspector that the property was smokeless, and thus secure the reduction of rate. There might be some difficulty at first in establishing a qualification, but it could not be greater than the difficulty of establishing a right to a parliamentary vote. In the course of time, the smoke producers would be a few exceptional persons paying exceptionally high rates, a very rational state of affairs; and when the City of London had by the gradual extension of such experiments freed itself from its own smoke, I think we might safely rely upon the citizens to take care that the indirect economies to which they would be legitimately entitled by their public spirit were not destroyed by the unrestricted smoke production of the surrounding boroughs.

I have made the system of the general collection of smoke by mechanical means for the purpose of treatment the basis of my remarks, but I have already disclaimed any desire for exclusive privileges for that particular form of experiment in the purification of smoky air. If it be feasible on the commercial scale, it has the advantage in an especial manner of making successive improvements possible. The smoky air of London is injurious, not only on account of its visible soot, but also on account of the sulphurous acid and other invisible products of combustion which accompany the soot in the first instance. If it be found possible in the first place to deposit the soot particles, attention might next be turned to some means of dealing with the noxious acid fumes, at least, in those cases where they are specially abundant.

Such a system would thus be, in the first instance, a direct encouragement to progressive experiments, and in the end would enlist the active support of all those possessing arrangements for avoiding smoke in favour of effective compulsion for those who had not.

To put the questions I have indicated to men of science in this way would be merely a matter of business, and if the questions were so put, the science of the twentieth century would probably give as satisfactory an answer to the question of the treatment of smoke as the science of the nineteenth has given to the question of the treatment of sewage.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Hon. C. A. Parsons, M.A., F.R.S., whose scientific work in connection with the development of the steam turbine has excited much interest, has been elected to an honorary fellowship at St. John's College, of which he was formerly a scholar.

Mr. L. Doncaster, King's, has been appointed to work at the University table in the Naples Zoological Station.

A conference on the training of teachers for secondary schools for boys will take place in Cambridge, under the presidency of the Vice-chancellor, in November.

The Gedge prize for research in physiology has been awarded to Mr. S. W. Cole, King's.

ON Wednesday, October 22, Mr. Andrew Carnegie was formally installed to the rectorship of St. Andrew's University. In his rectorial address, Mr. Carnegie dealt with the economic changes in the relative position and power of nations which either have taken place or are impending. Among honorary degrees conferred on the occasion was one bestowed on Mr. Alexander Graham Bell, the inventor of the telephone.

WHILE agricultural education is in a flourishing condition in the colleges of the United States, it is not yet doing as much for the welfare of the American farmer as is desirable. This, at least, we infer from the vigorous address delivered by the Secretary of Agriculture before the National Educational Association, which is briefly referred to in an editorial article in vol. xiv. part i. of the "U.S. Experiment Station Record." Mr. Wilson pleads not so much for technical instruction in agriculture as for the *education* of "half the people under our flag, who till the soil and furnish 65 per cent. of our exports." The importance of this class warrants the special adaptation of the educational system to its needs. "The four-year college course does not begin soon enough nor continue long enough to meet the requirements of our day." Study should begin in the primary school and continue through life. Teachers and the organisers of education in rural districts should understand the farmer's requirements, should themselves know something of agricultural science, and to this end Mr. Wilson recommends that teachers in primary and secondary schools should be sent to agricultural colleges at State expense to get the necessary knowledge. While much might be done to awaken the interest of the rising generation in agriculture were the teachers in elementary schools possessed of an agricultural bias, it is doubtful if any such "entirely new" system as Mr. Wilson refers to in the following sentence would be practicable or desirable. "Five thousand students attend agricultural colleges, but these colleges are feeling their way in the dark along untravelled paths. . . They will at last forge out a system that will meet the requirements of producers and be entirely new and suitable to our conditions as a people."

IN the *North British Agriculturist* of October 22, a different and more direct method of awakening the interest of the young farmer in his work is described. Under the auspices of the